

## NATURAL RESOURCES CONSERVATION SERVICE CONSERVATION PRACTICE STANDARD

### POND

(No.)

CODE 378

#### DEFINITION

A water impoundment made by constructing an embankment or by excavating a pit or dugout.

In this standard, ponds constructed by the first method are referred to as embankment ponds, and those constructed by the second method are referred to as excavated ponds. Ponds constructed by both the excavation and the embankment methods are classified as embankment ponds if the depth of water impounded against the embankment at the auxiliary spillway elevation is 3 feet or more.

#### PURPOSE

To provide water for livestock, fish and wildlife, recreation, fire control, develop renewable energy systems, and other related uses, and to maintain or improve water quality.

#### CONDITIONS WHERE PRACTICE APPLIES

This standard establishes the minimum acceptable quality for the design and construction of low-hazard ponds where:

Failure of the dam will not result in loss of life; damage to homes, commercial or industrial buildings, main highways, or railroads; or in interruption of the use or service of public utilities.

The product of the storage times the effective height of the dam is less than 3,000. Storage is the volume, in acre-feet, in the reservoir below the elevation of the crest of the auxiliary spillway. The effective height of the dam is the difference in elevation, in feet, between the auxiliary spillway crest and the lowest point in the cross section taken along the centerline of the dam. If there is no auxiliary spillway, the top of the dam is the upper limit.

The effective height of the dam is 35 feet or

less.

#### General Criteria Applicable to All Ponds

All federal, state, and local requirements shall be addressed in the design.

**Site conditions.** Site conditions shall be such that runoff from the design storm can be safely passed through (1) a natural or constructed auxiliary spillway, (2) a combination of a principal spillway and an auxiliary spillway, or (3) a principal spillway.

Sites shall be designed such that under normal climatic conditions, water will be available to meet the desired purpose. Rainfall runoff from the drainage area must be sufficient for the planned storage amount.

For purposes of providing a dry hydrant, guidance on availability of water can be found in Conservation Practice Standard 432, Dry Hydrant and in Engineering Technical Note OK-13.

**Drainage area.** The drainage area above the pond must be protected against erosion to the extent that expected sedimentation will not shorten the planned effective life of the structure. If there is excessive erosion upstream of the structure that is not controlled by the landowner, the effective life of a structure shall be obtained with the addition of sediment storage. The drainage area shall be large enough so that surface runoff and groundwater will provide an adequate supply and quality of water for the intended purpose unless an alternate water source exists to serve this purpose.

**Reservoir area.** The topography and geology of the site shall permit storage of water at a depth and volume that will ensure a dependable supply, considering beneficial use, sedimentation, season of use, and evaporation and seepage losses. If surface runoff is the

primary source of water for a pond, the soils shall be impervious enough to prevent excessive seepage losses or shall be of a type that sealing is practicable.

**Vegetation.** A protective cover of vegetation shall be established on all exposed areas of embankments, spillways, spoil areas, and borrow areas as climatic conditions allow, according to the guidelines in Conservation Practice Standard 342, Critical Area Planting.

Vegetation of embankments and excavated ponds shall include, at a minimum, all disturbed areas, except for areas upstream of the embankment where the vegetation minimum shall be two feet below the designed permanent pool elevation.

If soil or climatic conditions preclude the use of vegetation and protection is needed, nonvegetative cover such as mulches or gravel may be used. In some places, temporary vegetation may be used until permanent vegetation can be established. The embankment and auxiliary spillway shall be fenced if necessary to protect the vegetation.

### **Design Criteria for Embankment Ponds**

**Geological Investigations.** Pits, trenches, borings, review of existing data or other suitable means of investigation shall be conducted to characterize materials within the embankment foundation, auxiliary spillway and borrow areas. Soil materials shall be classified using the Unified Soil Classification System.

**Foundation cutoff.** A cutoff of relatively impervious material shall be provided under the dam if necessary to reduce seepage through the foundation. The cutoff shall be located at or upstream from the centerline of the dam. It shall extend up the abutments as required and be deep enough to extend into a relatively impervious layer or provide for a stable dam when combined with seepage control. The cutoff trench shall have a bottom width adequate to accommodate the equipment used for excavation, backfill, and compaction operations. Side slopes shall not be steeper than 1-1/2 horizontal to 1 vertical.

**Embankment seepage control.** Seepage control is to be included if (1) pervious layers are not intercepted by the cutoff, (2) seepage could create swamping downstream, (3) such control is needed to insure a stable

embankment, or (4) special problems require drainage for a stable dam. Seepage may be controlled by (1) foundation, abutment, or embankment filters and drains; (2) reservoir blanketing; or (3) a combination of these measures.

If dispersive clays are used in constructing the embankment, internal erosion shall be controlled by 1) soil treatment of the upper 1-foot of the embankment; and 2) the use of a filter drainage diaphragm or the use of soil treatment for all embankment material placed within at least a 2-foot minimum distance from the pipe conduit and riser. Soil treatment details shall include the following:

1. A soil/gypsum mixture consisting of 1% gypsum (by weight) should be used to construct the embankment material placed within at least a 2-foot minimum distance from the pipe conduit and riser.
2. The upper 1-foot of the embankment should be a soil/gypsum liner consisting of 3% gypsum (by weight).
3. The amount of gypsum required should be based upon a compacted soil density of 94 lbs/cu.ft.
4. Gypsum shall be thoroughly incorporated at moistures of optimum or greater with compaction at 90% of standard Proctor density.

**Embankment.** The minimum top width for a dam is shown in Table 1. Top widths are based upon the inventory height of the structure. If the embankment top is to be used as a public road, the minimum width shall be 16 feet for one-way traffic and 26 feet for two-way traffic. Guardrails or other safety measures shall be used where necessary and shall meet the requirements of the responsible road authority.

**Table 1. Minimum top width for dams**

Inventory Height <sup>1</sup> (ft.)	Top Width (ft.)
< 10	6
10-14.9	8
15-19.9	10
20-24.9	12
25-34.9	14
≥ 35	15

<sup>1</sup> Inventory height: Elevation difference between top of dam and lowest back toe elevation

**Side slopes.** The combined upstream and downstream side slopes of the settled embankments shall not be less than five horizontal to one vertical (5:1), and neither slope shall be steeper than two horizontal to one vertical (2:1). Oklahoma Water Resources Board regulated structures require a downstream slope no steeper than three horizontal to one vertical (3:1) unless a stability analysis is performed which shows a steeper slope provides an adequate factor of safety against sliding, sloughing or rotation in the embankment and foundation. All slopes must be designed to be stable, even if flatter side slopes than that described above are required. Downstream or upstream berms can be used to help achieve stable embankment sections.

**Slope protection.** If needed to protect the slopes of the dam from erosion, special measures, such as berms, rock riprap, sand-gravel, soil cement, or special vegetation, shall be provided (Technical Releases 56, "A guide for Design and Layout of Vegetative Wave Protection for Earth Dam Embankments" and 69, "Riprap for Slope Protection Against Wave Action" contain design guidance). The designer should review the need for such measures when (1) the maximum fetch length from any direction exceeds 700 feet or (2) the surface area of the permanent pool exceeds 5 acres.

**Freeboard.** The minimum elevation of the top of the settled embankment shall be 1 foot above the water surface in the reservoir with the auxiliary spillway flowing at design depth. The minimum difference in elevation between the crest of the auxiliary spillway and the settled top of the dam shall be 2 feet for all dams having more than a 20-acre drainage area or more than 20 feet in effective height.

**Settlement.** The design height (from design top of dam along centerline to natural ground) of the dam shall be increased by the amount needed to ensure that after settlement the height of the dam equals or exceeds the design height. Allowance for settlement shall be 5 percent of design height for dams constructed with a carryall and 10 percent of design height for dams constructed with a dozer or with both a dozer and carryall, unless detailed soil testing and laboratory analyses show that a lesser amount is adequate.

**Pipe length.** The principal spillway pipe length is computed using:

- a) Length in embankment computed using the design settled slope +0.2, AND
- b) additional pipe length (APL formula below) added to the dimension upstream of the centerline of the dam for shrinkage slope;
- c) additional pipe lengths at the upstream slope and/or the downstream toe as specified on the standard drawings.

The following formulas will be used to calculate added pipe length (APL):

$$APL = L - ENGR$$

$$L = (TDE + SH(CFH) - PSIE)(ZF/(1 + SH) + 0.2)$$

$$ENGR = (TDE - PSIE)(ZF + 0.2)$$

Where:

APL = Added Pipe Length

TDE = Top of Dam Elevation

SH = Shrinkage, in Decimal Form

CFH = Centerline Fill Height

PSIE = Principal Spillway Invert Elevation

ZF = Front Slope of Embankment

**Principal spillway.** A pipe conduit, with needed appurtenances, shall be placed under or through the dam, except where rock, concrete, or other types of lined spillways are used, or where the rate and duration of flow can be safely handled by a vegetated or earth spillway.

For dams with a drainage area of 20 acres or less, the principal spillway crest elevation shall not be less than 0.5 feet below the auxiliary spillway crest elevation. For dams with a drainage area over 20 acres, this difference shall not be less than 1.0 foot.

When a good earth spillway condition suitable to withstand frequent or prolonged flows can be obtained, a principal spillway conduit will not be required. Otherwise, a principal spillway conduit is required and shall be sized to pass the peak flow expected from a 24-hour duration design storm of the frequency shown in Table OK-1, less any reduction because of detention storage.

When design discharge of the principal spillway is considered in calculating peak outflow through the auxiliary spillway, the crest elevation of the inlet shall be such that the design discharge will be generated in the conduit before there is discharge through the auxiliary spillway.

The minimum principal spillway design storm in Table OK-1 is chosen according to the maximum drainage area, the dam effective height, and the condition of the auxiliary spillway. The following, combined with knowledge of local soil materials, should be used in determining the condition of the auxiliary spillway.

1. **Fair Spillway.** A fair spillway may have moderately steep uniform slopes, (uniform throughout its length with no overfalls), will outlet at base grade and will not have easily eroded soils (normally those with a high content of fine sand or silt and lower plasticity). A fair spillway has an existing minimum fair grass cover or fair potential for establishing a protective grass cover.
2. **Poor Spillway.** A poor spillway may have steep uniform slopes, will outlet at base grade and may have easily eroded soils. A poor spillway has an existing minimum poor grass cover or poor potential for establishing a protective grass cover.
3. **Very Poor Spillway.** A very poor spillway may have large overfalls, easily eroded soils, dispersive clays, or other problems of safely conveying the water to base grade. A very poor spillway has an existing minimum very poor grass cover or very poor potential for establishing a protective grass cover.

**Table OK-1. Minimum principal spillway capacity**

Maximum Drainage Area (ac.)		Dam Effective Height (ft.)	Minimum Principal Spillway Design Storm (Frequency: years)		
5-yr, 24-hour rainfall			Condition of Auxiliary Spillway		
3-5 in.	≥ 5 in.		Fair	Poor	Very Poor
100	50	≤ 35	2	2	5
200	100	≤ 20	2	2	5
200	100	20 - 35	5	5	10
400	200	≤ 20	2	5	10
800	400	≤ 20	2	10	10

If criteria values exceed those shown in Table OK-1, the 10-year frequency, 24-hour duration storm must be used as the minimum design storm.

Pipe conduits designed for pressure flow must have adequate anti-vortex devices. The inlets and outlets shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated.

The capacity of the pipe conduit shall be adequate to discharge long-duration, continuous, or frequent flows, without flow through the auxiliary spillway. The diameter of the principal spillway pipe shall not be less than 6 inches. If the pipe conduit diameter is 10 inches or greater, its design discharge may be deducted when calculating the peak outflow rate to be routed through the auxiliary spillway. It is recommended that the principal spillway or drawdown pipe be designed to empty the detention pool in 10 days or less.

Pipe conduits used solely as a supply pipe through the dam for watering troughs and other appurtenances shall not be less than 1-1/4 inches in diameter.

Pipe conduits shall be ductile iron, welded steel, corrugated steel, corrugated aluminum, reinforced concrete (pre-cast or site-cast), or plastic. In addition to the listed materials, pipe conduit material through dams of less than 20 feet total height can be cast iron or nonreinforced concrete. The maximum height of fill over any principal spillway conduit must not exceed 25-feet.

Corrugated steel pipes must have a protective coating suitable for installed conditions. All steel pipe and couplings shall have protective coatings in areas that have traditionally experienced pipe corrosion or in embankments with saturated soil resistivity less than 4000 ohms-cm or soil pH less than 5. Protective coatings shall be galvanized, asphalt, polymer over galvanized, aluminized coating, or coal tar enamel as appropriate for the pipe type. Plastic pipe that will be exposed to direct sunlight shall be ultraviolet-resistant and protected with a coating or shielding, or provisions provided for replacement as necessary.

Pipe conduits and watertight connectors under or through the dam shall be designed and installed to withstand all external and internal

design loads and pressures as well as loads that occur during shipping, handling, and installation without wall crushing, local buckling, excessive deflection, ring compression, ring bending, ring deflection, excessive expansion and contraction, or cracking. Rigid pipe shall be designed for a positive projecting condition (positive flow).

Flexible pipe shall be designed for a maximum deflection of 5 percent under the design load or as specified in Table OK-2 for polyvinyl chloride (PVC). The minimum thickness of flexible pipe shall be SDR 26, Schedule 40, or 16-gage as appropriate for the particular pipe material.

The modulus of elasticity for PVC pipe shall be assumed as one-third of the amount designated by the compound cell classification to account for long-term reduction in modulus of elasticity. Different reductions in modulus may be appropriate for other plastic pipe materials.

Connections of flexible pipe to rigid pipe or other structures shall be designed to accommodate differential movements and stress concentrations that could rupture the pipe.

All pipe conduits shall be designed and installed to be watertight by means of couplings, gaskets, caulking, waterstops, welding, or other approved means. Joints shall be designed to remain watertight under all internal and external loading including pipe elongation due to foundation settlement.

Specifications in Tables OK-3, OK-4, and OK-10 are to be followed for steel and aluminum corrugated pipe and welded steel.

Minimum effective wall thickness for welded steel pipe shall be followed according to Table OK-10. Minimum effective wall thickness is equal to the wall thickness minus maximum depth of rust or corrosion pits.

Inlets and outlets shall be structurally sound and made of materials compatible with those of the pipe. The inlet inverts shall be positioned no closer than 4 feet horizontally to the embankment unless protection from scour is provided.

Conduit type spillways such as canopy inlet, hood inlet, drop inlet, or orifice inlet shall be designed in accordance with national criteria or with Oklahoma NRCS state office approved

tables (see Table OK-6 for CMP canopy and hood inlets), data sheets, and standard drawings.

All risers shall be checked for floatation. A minimum factor of safety of 1.25 shall be used. Risers may be constructed of CMP, corrugated aluminum pipe (see Tables OK-5, OK-7, and OK-8) or welded steel (Table OK-10). Welded steel risers shall not exceed 60-inch diameter, and 60-inch diameter welded steel risers shall not exceed a height of 6 feet.

Pipe conduits shall have a concrete cradle or bedding if needed to provide improved support for the pipe that will reduce or limit structural loading on pipe to allowable levels. Cantilever outlet sections, if used, shall be designed to withstand the cantilever load. Pipe supports shall be provided when needed. Other suitable devices such as a Saint Anthony Falls stilling basin or an impact basin may be used to provide a safe outlet.

**Renewable energy.** For detailed criteria where the purpose is to develop renewable energy systems, refer to interim Conservation Practice Standard 716, Renewable Energy Production.

**Cathodic protection.** Cathodic protection is to be provided for coated welded steel and galvanized corrugated metal pipe where soil and resistivity studies indicate that the pipe needs a protective coating, and where the need and importance of the structure warrant additional protection and longevity. If cathodic protection is not provided for in the original design and installation, electrical continuity in the form of joint-bridging straps should be considered on pipes that have protective coatings. Cathodic protection should be added later if monitoring indicates the need.

**Pipe seepage control.** Seepage control along a pipe conduit spillway shall be provided if any of the following conditions exist:

- The effective height of dam is greater than 15 feet.
- The conduit is of smooth pipe larger than 8 inches in diameter.
- The conduit is of corrugated pipe larger than 12 inches in diameter.

Seepage along pipes extending through the embankment shall be controlled by use of a

filter and drainage diaphragm, unless it is determined that anti-seep collars will adequately serve the purpose.

**Drainage diaphragm.** The drainage diaphragm shall function both as a filter for adjacent base soils and as a drain for seepage that it intercepts. The drainage diaphragm shall consist of sand meeting the requirements of ASTM C-33, for fine aggregate. If unusual soil conditions exist such that this material may not meet the required filter or capacity requirements, a special design analysis shall be made.

The drainage diaphragm shall be a minimum of 2 feet thick and extend vertically upward and horizontally at least three times the outside pipe diameter or to within 2-feet of the surface of embankment whichever is less, and vertically downward at least 18 inches beneath the conduit invert.

The top of the drainage diaphragm shall have a minimum of 2 feet of cover. The drainage diaphragm shall be located immediately downstream of the cutoff trench, but downstream of the centerline of the dam if the cutoff is upstream of the centerline.

The drainage diaphragm shall outlet at the embankment downstream toe using a drain backfill envelope continuously along the pipe to where it exits the embankment. Drain fill shall be protected from surface erosion.

**Anti-seep collars.** When anti-seep collars are used in lieu of a drainage diaphragm, they shall have a watertight connection to the pipe.

Maximum spacing shall be 25 feet. Twenty-foot spacing is commonly used, and minimum spacing shall be 10 feet. Collar material shall be compatible with pipe materials. The anti-seep collar(s) shall increase by at least 15 percent the seepage path along the pipe. The seepage path (saturation zone length) is defined as the pipe barrel length within the embankment configuration meeting design top widths and design settled slope requirements.

The minimum projection of anti-seep collars shall be 2 feet. Table OK-9 shows the minimum number of anti-seep collars required for a 2-foot projection.

The minimum thickness of welded steel anti-seep collars is ¼-inch. The minimum thickness

for galvanized metal anti-seep collars is 14-gage for flat or 16-gage for corrugated. The minimum thickness of high density polyethylene plastic is ¼-inch.

**Trash guard.** To prevent clogging of the conduit, an appropriate trash guard shall be installed at the inlet or riser unless the watershed does not contain trash or debris that could clog the conduit.

**Other outlets.** A pipe with a suitable valve shall be provided to drain the pool area if needed for proper pond management or if required by State law. The principal spillway conduit may be used as a pond drain if it is located where it can perform this function.

**Auxiliary spillways.** Auxiliary spillways convey large flood flows safely past earth embankments and have historically been referred to as "Emergency Spillways."

An auxiliary spillway must be provided for each dam, unless the principal spillway is large enough to pass the peak discharge from the routed design hydrograph and the trash that comes to it without overtopping the dam. The following are minimum criteria for acceptable use of a closed conduit principal spillway without an auxiliary spillway: (1) a conduit with a cross-sectional area of 3 square feet or more, (2) an inlet that will not clog, and (3) an elbow designed to facilitate the passage of trash.

The minimum capacity of a natural or constructed auxiliary spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 2, less any reduction creditable to conduit discharge and detention storage.

The auxiliary spillway shall safely pass the peak flow, or the storm runoff shall be routed through the reservoir. The routing shall start either with the water surface at the elevation of the crest of the principal spillway or at the water surface after 10 days' drawdown, whichever is higher. The 10-day drawdown shall be computed from the crest of the auxiliary spillway or from the elevation that would be attained if the entire design storm were impounded, whichever is lower. Auxiliary spillways shall provide for passing the design flow at a safe velocity to a point downstream where the dam will not be endangered.

**Table OK-2. Acceptable PVC pipe for use in earth dams as a conduit<sup>1</sup>**

Fill over pipe (ft.)	Pipe Diameter (in.)				
	≤ 4	6	8	10	12
≤ 10	SDR 26	SDR 26	SDR 26	SDR 26	SDR 26
10.1 – 14.9	Schedule 40	Schedule 80	Schedule 80	Schedule 80	Schedule 80
15 – 20	Schedule 80	Not permitted	Not permitted	Not permitted	Not permitted

<sup>1</sup> Polyvinyl chloride pipe, PVC 1120 or PVC 1220, conforming to ASTM-D-1785 or ASTM-D-2241**Table OK-3. Minimum gages for corrugated metal pipe (CMP) used as a conduit**

Fill Height <sup>1</sup> (ft.)	1½” X ¼” corrugated (Ga.)			2⅔” X ½” corrugated (Ga.)					3” X 1” corrugated (Ga.)				
	Diameter (in.)			Diameter (in.)					Diameter (in.)				
	6	8	10	≤ 24	30	36	42	48	≤ 36	42	48	54	60
< 15	16	16	16	16	16	14	12	10	16	16	16	16	16
15 – 19.9	16	16	16	16	16	14	12	10	16	16	16	14	14
20 – 25	16	16	16	16	14	12	10	10	16	16	14	12	12

<sup>1</sup> Fill height measured from top of pipe along the centerline**Table OK-4. Minimum thickness for corrugated aluminum pipe<sup>1</sup> (2⅔" x ½" corrugations) used as a conduit**

Fill Height <sup>2</sup> (ft.)	Thickness (in.)			
	Diameter (in.)			
	≤ 21	24	30	36
< 15	.06	.06	.075	.075
15 – 19.9	.06	.075	.105	.105
20 – 25	.06	.105	.135	<sup>3</sup>

<sup>1</sup> Riveted or helically fabricated pipe<sup>2</sup> Fill height measured from top of pipe<sup>3</sup> Not permitted**Table OK-5. Maximum height of corrugated aluminum risers<sup>1</sup> (2⅔" x ½" corrugations)**

Diameter (in.)	Gage (Thickness (in.))			
	14 (0.075")	12 (0.105")	10 (0.135")	8 (0.164")
24	20	20	20	20
30	20	20	20	20
36	20	20	20	20
42	17	20	20	20
48	12	17	20	20
54	8	12	15	20
60	6	8	11	14
66	5	6	8	11
72	4	5	6	8

<sup>1</sup> Maximum height limit is 20 feet for corrugated aluminum pipe

**Table OK-6. Thickness and stiffener requirements for CMP canopy and hood inlets**

Pipe Diameter (in.)	Corrugations	<sup>1</sup> Head (ft.)	Min. Ga.	Stiffener 1" X 1½" X ¼" Angle Iron, welded on corrugations
24	2⅔" X ½"	≥ 15	12	None
30	2⅔" X ½"	≥ 15	12	None
36	2⅔" X ½"	≥ 15	12	Both Sides
≥ 42	3" X 1"	< 10	14	None
≥ 42	3" X 1"	10-14.9	12	None
≥ 42	3" x 1"	≥ 15	12	Both Sides

<sup>1</sup>Head is measured from the auxiliary spillway crest to the centerline of the pipe of the outlet

**Table OK-7. Minimum gages for CMP risers (2⅔" x ½" corrugations)**

Riser Height (ft.)	Riser Diameter (in.)										
	30 & less	36	42	48	54	60	66	72	78	84	96
8 or less	16	16	16	14	14	14	12	12	12	10	10
8.1 – 12	16	16	16	14	14	12	12	12	10	10	10
12.1 – 15	16	16	14	14	12	12	10	10	10	--	--
15.1 – 20	16	14	14	12	10	--	--	--	--	--	--

**Table OK-8. Minimum gages for CMP risers (3" x 1" corrugations)**

Riser Height (ft.)	Riser Diameter (in.)										
	42 & Smaller	48	54	60	66	72	78	84	96	108	120
8 or less	16	16	16	16	14	14	14	14	12	12	10 <sup>1</sup>

<sup>1</sup>12-gage if total riser height less than 7.3 feet

**Table OK-9. Minimum number of anti-seep collars**

Saturation Zone Length (ft.)	Anti-seep Collars (no.)
≤42	1
42-69	2
70-97	3
98-125	4
126-153	5

**Table OK-10. Minimum effective wall thickness for welded steel pipe conduit and risers**

Pipe diameter (in.)	Thickness (in.)
<14	0.158
14-24	0.220
>24-36	0.282
>24 to 60 (risers only)	0.250

Constructed auxiliary spillways are open channels that usually consist of an inlet channel, a control section, and an exit channel. They shall be trapezoidal and shall be located in undisturbed or compacted earth or in-situ rock. The side slopes shall be stable for the material in which the spillway is to be constructed. For dams requiring a constructed auxiliary spillway or having an effective height higher than 20 feet, the auxiliary spillway bottom width shall not be less than 10 feet.

The inlet channel may be curved to fit existing topography and should have a slope toward the reservoir of not less than 2.0 percent, except in rock, to insure drainage and low inlet losses.

The level portion of the inlet channel (the control section) shall be level for the distance needed to protect and maintain the crest elevation of the spillway but not less than 25 feet. The grade of the exit channel of a constructed auxiliary spillway shall fall within the range established by discharge requirements and permissible velocities.

Additional guidance on the layout and design of earth spillways can be found in Part 628, Chapter 50 of the National Engineering Handbook and Chapter 11 of the Engineering Field Handbook.

**Table 2. Minimum auxiliary spillway capacity**

Drainage area (Ac)	Effective height of dam <sup>1</sup> (Ft)	Storage <sup>3</sup> (Ac-Ft)	Minimum design storm <sup>2</sup>	
			Freq. (Yrs)	Minimum duration (Hrs)
≤ 20	≤ 20	< 50	10	24
≤ 20	> 20	< 50	25	24
> 20	< 20	< 50	25	24
All others			50	24

<sup>1</sup> As defined under "Conditions where Practice Applies"

<sup>2</sup> Select rain distribution based on climatological region

<sup>3</sup> Storage at auxiliary spillway elevation

**Lined or other structural spillways.** If chutes or drops are used for principal spillways or auxiliary spillways, they shall be designed according to the principles set forth in Part 650 of the Engineering Field Handbook and the National Engineering Handbook, Section 5, Hydraulics; Section 11, Drop Spillways; and Section 14, Chute Spillways. The minimum capacity of a structural spillway shall be that

required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 2, less any reduction creditable to conduit discharge and storage.

### **Design Criteria for Excavated Ponds**

**Runoff.** Provisions shall be made for a pipe and auxiliary spillway, if needed, that will meet the capacity requirements of Table 2. Runoff flow patterns shall be considered when locating the excavated pond and placing the spoil.

**Side slopes.** Side slopes of excavated ponds shall be stable and shall not be steeper than 1 horizontal to 1 vertical. If livestock will water directly from the pond, a watering ramp of ample width shall be provided. The ramp shall extend to the anticipated low water elevation at a slope no steeper than 3 horizontal to 1 vertical.

**Inlet protection.** If surface water enters the pond in a natural or excavated channel, the side slope of the pond shall be protected against erosion.

**Excavated material.** The material excavated from the pond shall be placed so that its weight will not endanger the stability of the pond side slopes and it will not be washed back into the pond by rainfall. It shall be disposed of in one of the following ways:

- Uniformly spread to a height that does not exceed 3 feet, with the top graded to a continuous slope away from the pond. Spoils exceeding 3-feet shall be placed and compacted according to the embankment criteria.
- Uniformly placed or shaped reasonably well, with side slopes assuming a natural angle of repose. The excavated material will be placed at a distance equal to the depth of the pond but not less than 12 feet from the edge of the pond.
- Shaped to a designed form that blends visually with the landscape.
- Used for low embankment construction and leveling of surrounding landscape.
- Hauled away.

### **Design Criteria for Commercial Fishponds**

Water impoundments constructed and managed for commercial aquaculture production shall be

designed and constructed according to Conservation Practice Standard 397, Commercial Fishponds.

### **Design Criteria for Wetland Restoration, Creation, or Enhancement**

Water impoundments constructed for the purpose of restoring, creating, or enhancing wetlands shall be designed and constructed according to Conservation Practice Standards 657, Wetland Restoration, 658, Wetland Creation, 659, Wetland Enhancement, and 587, Structures for Water Control as appropriate.

### **CONSIDERATIONS**

**Embankment width.** For dams less than 20 feet in height, maintenance considerations or construction equipment limitations may require increased top widths from the minimum shown in Table 1.

**Livestock access.** Refer to Conservation Practice Standard 575, Animal Trails and Walkways, for appropriate design criteria. Where livestock have access to the pond, the structures, earthfill, vegetated spillways, and other areas should be fenced as necessary to protect the structure and reduce turbidity. Livestock should be excluded from the pond when an alternate water source exists.

**Visual resource design.** The visual design of ponds should be carefully considered in areas of high public visibility and those associated with recreation. The underlying criterion for all visual design is appropriateness. The shape and form of ponds, excavated material, and plantings are to relate visually to their surroundings and to their surroundings and to their function.

The embankment may be shaped to blend with the natural topography. The edge of the pond may be shaped so that it is generally curvilinear rather than rectangular. Excavated material can be shaped so that the final form is smooth, flowing, and fitting to the adjacent landscape rather than angular geometric mounds. If feasible, islands may be added for visual interest and to attract wildlife.

**Cultural resources.** Consider existence of cultural resources in the project area and any project impacts on such resources. Consider conservation and stabilization of archeological,

historic, structural, and traditional cultural properties when appropriate.

**Fish and wildlife.** Project location and construction should minimize the impacts to existing fish and wildlife habitat. Refer to Conservation Practice Standards 399, Fish Pond Management and 644, Wildlife Wetland Habitat Management for additional information.

Consider the following items during practice design, construction, and operation and maintenance plan development to improve fish and wildlife habitat:

- Effects of construction and water impoundment on existing fish and wildlife habitat.
- Size of pond in order to provide suitable space and habitat for fish and aquatic wildlife. Surface area of at least one-half acre is recommended.
- Depth of water in order to provide desired habitat conditions for targeted fish and wildlife species and overcome effects of temperature and precipitation. Water at least 10 feet deep over 25 percent of the surface area is recommended for fish. Water depths of 6 to 18 inches are recommended for waterfowl.
- Effects of shoreline slope on aquatic plant growth. Steeper slopes reduce aquatic plant growth and flatter slopes increase aquatic plant growth.
- Installation of drainpipe to control water levels and provide opportunities for fish and wildlife management.
- Leaving brush, stumps, and/or installing artificial structure for fish habitat during pond construction.
- Timing of mowing with respect to ground-nesting bird species' egg-laying, hatching, and fledging.

**Vegetation.** Stockpiling topsoil for placement on disturbed areas can facilitate revegetation.

Consider placement and selection of vegetation to improve fish and wildlife habitat species diversity.

**Water quantity.** Consider effects upon components of the water budget, especially:

- Effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
- Variability of effects caused by seasonal or climatic changes.
- Effects on downstream flows and impacts to (1) environment such as wetlands and aquifers and (2) social and economic downstream uses or users.
- Potential for multiple purposes.

**Water quality.** Consider the following during practice design and construction:

- Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances that are carried by runoff.
- Effects on the visual quality of onsite and downstream water resources.
- Short-term and construction-related effects of this practice on the quality of downstream water courses.
- Effects of water level control on the temperatures of downstream water to prevent undesired effects on aquatic and wildlife communities.
- Effects on wetlands and water-related wildlife habitats.
- Effects of water levels on soil nutrient processes such as plant nitrogen use or denitrification.
- Effects of soil water level control on the salinity of soils, soil water, or downstream water.
- Potential for earth moving to uncover or redistribute toxic materials such as saline soils.

## PLANS AND SPECIFICATIONS

Plans and specifications for installing ponds shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## OPERATION AND MAINTENANCE

A written operation and maintenance (O&M) plan shall be developed and reviewed with the landowner or individual responsible for operation and maintenance.

The operation and maintenance plan shall include at minimum:

1. Inspection after heavy rains for possible damage:
  - a. Repair of damage if found.
  - b. Clearing accumulated trash from pond spillways, both principal and auxiliary.
2. Regular mowing, fertilization, and removal of excess growth and trees from the embankment.
3. Annual inspections including:
  - a. Repair of damage from normal use, including the inlet and outlet of the principal spillway, embankment, and auxiliary spillway if present.
  - b. Checking downstream toe for wet areas or seeps; report of such to the local NRCS field office.
  - c. Re-seeding in areas lacking erosion protection.
  - d. Removing burrowing animals if present.
  - e. Maintenance of fence and/or stock-water system if present.